Life as a Making

Perig Pitrou
Paris Research University, CNRS
Pépinière interdisciplinaire CNRS-PSL 'Domestication et fabrication du vivant'

Life is a protean phenomenon, one that manifests itself at multiple levels and captures the attention of humans everywhere. It would be rash to claim that people across the globe perceive vital processes—such as growth, reproduction, senescence, and death—in the same way. However, it is clear that in the vast majority of instances, vital processes are obvious enough to retain human attention, so much so that we can confidently say that every human society develops explanatory systems in order to render these processes intelligible and, when possible, to act upon them. The major difficulty stems from the fact that the causes of these phenomena remain partially obscured from view. Notwithstanding the progress that has been made in medical imaging, it is as if life's very action—its power to shape and to organize, to make beings interact with their environments, to cause them to regenerate or reproduce—remains hidden within the folds of matter, so that humans must deploy all their ingenuity to construct etiological explanations. Having observed this, it becomes clear that we ought to distinguish 'living' or 'being alive' from 'making live' [*faire vivre*], and that we must not confuse the observable functional characteristics of living beings with the causes that produce them, whether internal or external, visible or invisible.

NatureCulture 2017

Surprisingly, although the distinction is obvious, anthropologists engaged in comparative studies on this subject rarely invoke it: the terms 'life', 'alive', and 'being alive' often appear as synonyms (Pitrou 2014, 2015a). In order to avoid such semantic confusion and to define the realities to which these terms refer, it seems to me more accurate to choose the term 'life' to designate the set of causes that makes it such that beings are considered 'living beings' or 'alive'. Far from suggesting that these concepts refer to universal realities, I propose using them as provisional demarcations, as invitations to take a new look at the diverse array of conceptions of life and the living that prevail in human societies—much in the same way that the anthropologist of nature Philippe Descola (2013) sought to depict the multiplicity of conceptions of 'nature'.

I became aware of the importance of these issues during two and a half years of ethnographic fieldwork over the period of 2005 to 2015, among the Mixe, an Amerindian people living in peasant village communities located in the Sierra Norte of Oaxaca, Mexico (Pitrou 2016a). My exploration of animal sacrifices performed by the Mixe in agricultural, therapeutic, and political contexts allowed me to ascertain that prayers uttered in the vernacular language are often addressed to a non-human entity known as 'The One Who Makes Being Alive' as well as to associated entities such as the Rain, the Wind, and the Earth. Starting off from the postulate that the actions imputed to this entity trace the contours of what I call 'a theory of life', I proposed interpreting life as a 'process of making': that is, as a set of actions performed by this non-human agent to encourage vital processes in agricultural rites (Pitrou 2014) or birth rites (Pitrou 2017). Depending on the situation, this agent may be called upon to 'distribute' the rain so that corn will grow, or to 'bake' the body of a newborn child, just like a potter firing his pieces. In this context, *making* includes various kinds of technical activity combined into sequences or a set of sequences. For example, there may be techniques of the body (a *doing*), cognitive techniques of measurement, techniques involving the use of tools, techniques of shaping or composition, and so on. At the same time, envisioning life as a making means that the specificity of this agency can be approached through the question of form, matter, measure, movement, composition, etc. A comparative study with Amazonia and Oceania (Pitrou 2016b; Pitrou, Coupaye & Provost 2016) has convinced me, furthermore, that this way of viewing matter is applicable not only to the Mixe. An approach inspired by pragmatics, one that focuses on the categories of action and agency thought to encourage vital processes, is useful for understanding the plurality of conceptions of life found across the planet.

Adopting this point of view allows us to avoid treating life abstractly, like some sort of uniform flow circulating between bodies. Although the dynamics

specific to such circulation should be studied, I argue that to understand life it is necessary to reproduce what I call 'agentive configurations' (Pitrou 2015a, 2017). With this notion, I suggest that instead of taking 'life' in a very general way, as if humans could have an unmediated connection with this phenomenon, it is more relevant to consider their knowledge of life as arising from a multiplicity of relations and interactions that they establish with living beings. From this point of view, I have suggested, then, to develop an approach able to describe the many vital processes at work in a given context, as well as the diversity of actions humans take to influence—or try to influence—these processes. My fieldwork also led me to understand that the actions of 'The One Who Makes Being Alive' should be analyzed in connection with the actions the Mixe take to influence his agency, in particular through what I call a 'regime of co-activity'. For example, by distributing materials on a miniature ceremonial deposit they attempt to ritually connect the action of distributing corn throughout a field with the action of distributing the rain thought to cause growth (Pitrou 2014, 2016a). On the basis of this theoretical construction, which translates *emic* concepts into *etic* ones, I suggest that it is instructive to describe the modes of *coordination* between life (that is, the causes, internal or external, personified or not, that make living beings alive) and the actions humans take to influence these processes. In my conclusion, I explain that we must also take into account the actions that other living beings may perform on humans. My argument here is that in order to explore 'agentive configurations' it is necessary to analyze the modalities of technical actions taken within them. It is my contention that the diverse array of such technical activities can be treated *both* as models of intelligibility that allow humans to imagine functions that they cannot observe *and* as the concrete modalities of action humans use to increase and refine their power over the living.

In an excellent doctoral dissertation entitled 'Crafting life: A sensory explanatory of fabricated life' (2010)—the basis for the book *Synthetic: How life got made* (2017)—Sophia Roosth also defends the idea that 21st-century conceptualizations of the living should be analyzed through studies of various activities 'of making', in particular in the domain of synthetic biology or 'DIY biology'. I am in complete agreement with the two ideas at the basis of Roosth's argument. First, as Stefan Helmreich has been brilliantly showing for the last twenty years, the concept of life, which has been in crisis, is being completely reshaped—and not only in scientific circles. Second, it is crucial to connect human conceptions of the living with actual practices—to treat 'knowing as making and making as knowing', to quote the title of one of Evelyn Fox Keller's articles (2009). However, my goal is different from Roosth's, first of all because my analysis goes beyond the field of science and technology studies. I do not mean to deny the

importance that the reconfiguration of the living within the sciences has had over the past several decades and the epistemological problems it raises. However, my focus is on exploring how, well before the development of biotechnologies, humans used technical activity to conceptualize the agency specific to life. This is why the anthropology of life I am developing seeks to build a comparative framework that leaves room for ethnographic data gathered in non-Western traditional societies. The epistemological reflection that anthropology has undertaken of the notion of life seems to follow a path similar to the critical enterprise that tackled the notion of nature from two centers: science and technology studies (Franklin 1997; Latour 1993; Mol 2002) and the ethnology of non-Western societies (Descola 2013; Ingold 2000; Strathern 1992; Viveiros de Castro 2012). A good example of this dynamic can be found in Gílsi Pálsson's *Nature, culture and society: anthropological perspectives on life* (2015). Now, it seems to me that the notion of 'agentive configurations' provides us with a consistent heuristic tool for studying the conceptions of life that dominate in very different societies (modern/non-modern; Western/non-Western). In order to prove the analytic benefit of this pragmatics-inspired approach, we must go into detail and identify the intellectual and material techniques that allow humans to maintain an always-mediated relationship with vital processes.

Thus, my intention is not so much to consider actions such as crafting, making, or doing as categories that would encompass a set of dissimilar practices (for example, synthetic biology and crocheting with coral and wool yarn (Roosth 2013)). To the contrary, it seems richer to start from the principle that making refers to a plurality of activities, each one having its own specific traits and shedding light on different aspects of life. The goal of this article is to offer a first look at this diversity by recalling that the notion of technique, which is quite vast, refers to a set of practices that are highly diverse and sometimes complementary but never reducible to one another. Techniques of the body, cognitive techniques, craftwork, construction, manufacturing, production, engineering, technology, artistic techniques, and *bricolage* are all activities that allow humans to intervene in the world, sometimes in order to modify their relations to other living beings using specific modalities. In order to systematically organize—synchronically and diachronically—the agentive configurations that correspond to these techniques, an in-depth investigation is indispensable to my anthropological project and to the goal of comparing variations in conceptions of life across time and space. The brief inventory provided in this article is meant to be a preliminary study for a larger project; it aims to sketch out some initial directions that a comparative study might take.

Life as Artcraft: Creating, Shaping, and Building

Since antiquity, the distinction between *technè* and *phusis* has provided a heuristic model for understanding the specificity of the activities that take place within natural beings, the mechanisms of which are difficult to observe (Canguilhem 1965 [1952]). For instance, the analogy between living beings and artifacts makes it possible to represent the action of growth by comparing it to that of the artisan who shapes objects by performing an external action, just as nature appears to do from inside living beings. Of course, this distinction should not be treated as a rigid dichotomy: on the one hand, according to Aristotle, at a certain level, the artisan's activity is considered to be the extension of a natural movement; on the other hand, often it is the imbrication of vital processes and technical processes that can teach us the most (Pitrou, Coupaye & Provost 2016). However, this analogy is a good starting point for understanding the sense in which technical activity—here, craftwork—helps humans render life intelligible. Without going so far as to claim that technical activity is fully exoteric, we may say that it belongs to a field of practice in which humans, because of the driving role they play in it, have more knowledge, when compared with their grasp of the domain of vital processes. This is why many creation myths turn to metaphors involving techniques to illustrate how living beings were created as well as to explain the functional characteristics they display.

Among the Mixe, a myth explains how 'The One Whose Activity is to Have Ideas' (*täätyunpï*) created the beings of the world:

1. *täätyunpï*	'The One Whose Activity is to Have Ideas'
2. *jaayïp yï*	in the beginning
3. *tsyoo'ntä'äky tsoo'ntä'äkyïp*	he begins [to invent/to create]
4. *et näxwii'nyït meet*	the Expanse, the Surface of the earth
5. *yï täätyunpï*	'The One Whose Activity is to Have Ideas'
6. *mäjï na'apï mäjï kojpï*	just as the potter, the weaver
7. *na'apï ëë'pyï* […]	makes pottery, bends [the fibers to weave them] […]
8. *nayïtë'n*	in the same way
9. *tyanïpïktääjkïp*	he deposits the elements (= he builds the earth)
10. *täätyunpï*	'The One Whose Activity is to Have Ideas'
11. *tyanïwejtsïp*	he orders
12. *sutsooj ja tyïk'ëyït*	how to build
13. *ja tsïnaapyïtï ja jää'tyï*	the seated, the people (= the humans)
14. *pën jatë'n tsïnaatyïp*	who are thus seated (= who exist)
15. *ja jïyujktï ja ujtstï*	the animals, the plants
16. *tuki'yï tum yë' ntejïnt*	all this truly, it is said,

17. yïktamïjää'wïp	it is believed that
18. tnïkëjxp'aty	he carries it (= that the Creator keeps these beings in existence)
19. yë'ts tyïkëë'yïp	those he causes to be built
20. ja ujts ja kipy ja tsääj	the plants, the trees, the stones

The diversity of actions imputed to this agent offers a first glimpse of the complexity of the theory of life contained within the myth. From a material point of view, his activity is understood through analogies with pottery that shapes beings, and the manipulation of plant fibers in basket-making or house-building that creates a framework. Life thus appears as the activity of composing heterogeneous elements that are manipulated in order to give a being its form and structure, as attested by the presence of a third verb used to refer to the intervention of the demiurge as a 'construction'. This construction is described literally as a 'depositing' (*pïktä'äky*), a term that refers to the internal organization of an organism as well as the organization of relationships between beings, such as, for example, the hierarchy that dictates which living beings are eaten by others. In another part of the myth, there is also reference to the breath that animates beings once they have been shaped, built, and organized. It is said that 'The One Who Makes Being Alive' gives vitality (*yë' yïkjujykypyëjkp*). We can note immediately that the conceptualization of life passes through a set of representations of the plurality of causes, irreducible to one another, which are at the origin of phenomena observable among living beings. Beyond the question of whether a being is animate or not—a question that sometimes monopolizes the attention of anthropologists—the technical or technicist analogy offers access to a set of relations that occur at the level of organisms as well as within environments.

In order to fully understand the lessons contained in these types of analogy, we must note that they imply the idea of *process*, which thus rules out reducing technical activity to an isolated gesture. To the contrary, origin stories that describe how objects are made—in our case, living beings—more or less explicitly depict what Pierre Lemonnier calls 'mythical operational chains' (2004), that is, series of heterogeneous actions performed by a plurality of agents who coordinate their engagement with material. For example, by comparing the morphogenetic process to pottery-making, the reference is not solely to an action of modeling. Such action can occur only as part of a longer sequence of distinct operations that involves techniques of the body as well as cognitive techniques (counting, predicting, and so on) converging to construct a being: cutting wood, lighting a fire, building an oven, gathering earth.

This emphasis on synchronic and diachronic co-ordination and on heterogeneous actions accounts for the fact that the role I attribute to techniques in explaining vital mechanisms differs from the one recognized by Tim Ingold (Pitrou, Coupaye & Provost 2016). Ingold's phenomenological approach, from *The perception of the environment* (2000) to *Making* (2013) by way of *Being alive* (2011), leads him to discern a manifestation of life in technical acts. The resemblances between certain artifacts and living forms—for example, the spiral patterns visible on baskets and on the shells of mollusks—attest, according to Ingold, to a continuity between the living body of the artisan, which moves to its own rhythm, and the body of the material on which he acts—in the same way that a shell preserves within itself the traces of an *élan vital*. *Making and growing* (Hallam & Ingold 2014) offers many examples of this dynamic, in which materials, far from being shapeless substances shaped by human action, are treated as milieus with which the body interacts, giving birth to the material forms of objects and to artisans' know-how.

This approach naturalizes the technical act and takes it as a manifestation of life understood as a movement. Though quite interesting and rather convincing, it cannot claim to sum up, by itself, all the relationships that exist between life and technique (for a detailed critique, see Pitrou 2014). While it is true that *in certain sequences* it is enough to underscore the continuities and isomorphisms between morphogenesis and technical acts, the complexity of vital phenomena—and thus, of the technical configurations that can represent them—is clearly much greater. Consequently, if technical activity helps humans better understand life, it is only by taking into account a *set* of actions, the organized combination of which can bring a being—whether living or artifactual—into existence. Ingold is certainly right to criticize a hylomorphism that interpreted technical activity as merely giving form to inert matter on the basis of mental representations. However, his criticism is weakened by his rejection of the heuristic value of the concept of an operational sequence (*chaîne opératoire*), a descriptive tool that is in fact particularly well suited to understanding the essential heterogeneity of technical activity and its capacity to combine agents, operations, and materials in order to make beings (Latour 2012; Lemonnier 2012).

The work of Ludovic Coupaye (2013) on the Abelam of Papua New Guinea demonstrates the significance of studying yams as 'growing artifacts', that is, as living beings whose appearance and properties depend on a multiplicity of actions performed by human and non-human agents who co-ordinate their interventions in making these plants grow. As is the case with made objects, the many different characteristics of living beings cannot be explained in terms of a single uniform movement imprinting matter, nor can the process of creation be adequately grasped

through the opposition between form and matter—if for no other reason than that principles of measurement must also be taken into account. For example, in pottery, the act of shaping must be accompanied by operations through which amounts of materials are apportioned and assembled and cooking time is calculated. Instead of postulating a movement or rhythm of the world that encompasses all beings and thus dissolves the distinction between the living and the non-living it seems more productive to approach technique and life through an analytic framework that acknowledges the diversity of phenomena these activities involve: energy, movement, matter, measurement, processes of decomposition and re-composition—to mention only a few examples.

In so doing, I am not seeking to defend a philosophical position on what life is. My goal, rather, is to examine how conceptions of life orient concrete practices. The technicist metaphor does not only provide plausible scenarios to explain the apparition of phenomena linked to life: it is also very actively applied to act on living beings. Thus, the connection between conceptions of life and technical activities works in both ways. If vital processes can be treated as analogous to technical processes, in return, technical processes are mobilized in order to act on living beings. As Arthur M. Hocart suggests in *The life-giving myth* (1952), myths should be interpreted as explanatory systems. Many of them contain a 'science of life', which is put into practice in rites—a way of acting upon vital processes, by acting either directly on living beings (human, animal, or plant), or indirectly, by soliciting the participation of entities that are thought to 'make live' or 'make being alive'. For example, among the Mixe, the 'Creator's' activity is not limited to creating the world and the Creator is expected to participate in the birth of each child. Ritual baths are given to newborns so that they will become 'strong, hard', and so, in a sense, that they will be 'cooked' by heat. Prayers are addressed to the Creator so that he will guide the shaping of the infant's body (Pitrou 2017). Here, we see that if life is understood in terms of the activity of pottery-making, symmetrically, the living person is understood as a being who, just like an artifact, has to be shaped and built.

Beyond the Mesoamerican world, other examples of this circularity between conceptions and practices can be found in the lowlands **of** South America, where procedures for constructing and giving form to persons beginning with their birth resemble the operational sequence used to make artifacts (Fortis 2014; Lagrou 2007; Pitrou 2016b, 2017; Praet 2013; Santos-Granero 2009). Santos-Granero's 'constructional approach', which is based on his ethnographic work among the Yanesha of the Peruvian Amazon, demonstrates the links between myths and rites in this process of making personhood. Just as it is thought that demiurges created the beings of the world with a mixture of earth and bodily substances, Yanesha

families believe that they must create their children generation after generation. In this process, the agency of plants, artifacts, animal elements (such as feathers and bones), and the bodily substances of the parents are carefully identified—making it possible to grasp the composite nature of subjectivities among the Yanesha. Santos-Granero identifies two principal modes by which living beings incorporate outside elements: 'embodiment, which entails the incorporation through objectivation of external substances and subjectivities, and ensoulment, which involves the incorporation through subjectivation of external artifacts and bodily substances' (2012: 198).

On the other side of the Pacific, in China, the practices described in *Ten thousand things: nurturing life in contemporary Beijing* (Farquhar & Zhang 2012) demonstrate that, as in the sense of Foucauldian 'practices of the self', persons are not merely objects formed by techniques: they build and shape themselves. According to Qicheng Zhang, '"The Chinese ancients" […] saw their lives as nothing if not susceptible to active forming and crafting' (13). In order to study this 'tradition of self-cultivation' (*zixiu*), which continues today, the authors study residents of Beijing who "actively seek to form and craft—to nurture (*yang*)—their lives' (13). Although this conception leads to an abstract elaboration within the Chinese philosophical view, it is above all through techniques—bodily, culinary, artistic, and so on—that they can be illustrated. Indeed, any action made with and on the body may provide information about which dynamic energies, associated with *qi*, are mobilized and channeled.

Once we begin to see technical activity as something more than a convenient metaphor for thinking about life, and understand it instead as an activity that combines technical and vital processes, we open the way to inquiries that take into account the relational dimension of life and the agency specific to the living. In order to further explore this dimension, I will now turn to views of life as a production.

Processes of Production

From the moment humans attempt to exert control over vital processes, including those that occur within their own bodies, they discover that their power over the living is never total. To the contrary, they must constantly adapt their actions depending on mechanisms that produce their own effects, something Alfred Gell explains nicely when he writes that 'all living things are agents with respect to themselves in that their growth and form may be attributed to their own agency' (1998: 41). A gardener may change the quantity of water he uses to grow his plants, but the process of growth remains a phenomenon that occurs without his

participation. Contraception increases control over reproductive cycles, while medically-assisted procreation resolves problems linked to infertility. However, the process of reproduction itself, in which the encounter between spermatozoids and ovocytes initiates embryogenesis, remains an event that humans can encourage, but not entirely control. We could add more examples by looking at how biotechnologies, archaic as well as contemporary, always mark the boundaries of a zone of uncertainty and alterity specific to life, a space within which humans can act only indirectly.

In a seminal paper (1962), André-Georges Haudricourt outlined a grammar of actions that could be used to classify the wide variety of ways humans treat animals and plants, in particular to correlate it with the way humans are treated in sociopolitical organizations (see also Descola 2013; Ferret 2012). Whereas yam cultivation in Oceania is based on 'indirect negative action', taken not on the domesticated being but rather on the milieu that surrounds it, pastoral activity in the Mediterranean basin mobilizes 'direct positive action', which requires constant attention to the herd. At a deeper level, it seems to me that this range of actions ultimately depends on the vital processes that humans observe among living beings, and from whose products they attempt to benefit. In a little-known text fundamental for approaching the question of the imbrication of vital and technical processes, François Sigaut (1980) remarks that 'humans use many different plant species, but each one in just a few ways, whereas they only use a few animal species, but each one in many ways'. He proposes an analytic table focusing on three animals—dogs, pigs, and roosters/hens—to indicate the variety of products humans derive from these beings. His goal is methodological above all: to emphasize through these examples the diversity of biomaterials and animal behaviors that humans in different societies enlist for their own enterprises. In order to study this type of configuration, Sigaut proposes 'taking the point of view of the providing animal. The things the animal provides have been named "products", to indicate that from the moment they are collected, they enter into an operational sequence (a product, in other words, is a thing that has economic significance)' (1980: 21, emphasis original).

We have seen that life may be understood as a process of shaping and building in which a living being is bit by bit given its specific characteristics. With the notion of the providing animal, the emphasis is on the capacity of each living being to supply energy or to carry out activities of transformation on its own. In deciding to consider 'life as a making', it is certainly not sufficient to conceive of the creation of living beings as the result of technical activity. We must be attentive to a sort of delegation of agency, whereby living beings are themselves makers, or rather, producers. In describing his concept of 'product', Sigaut specifies that:

> it is sometimes necessary to distinguish several products belonging to the same anatomic category on the basis of the uses they are intended to serve […] [F]at, for example, may be gathered differently depending on whether it is to be used for food, lighting, or other uses (lubricating cart axels, soaking metal, etc.). *The 'same' thing can give birth to several different 'products'*. (1980: 24, emphasis added)

Parallel to the *plasticity* of forms, living beings are characterized by the *diversity* of elements that comprise them and by the *potentiality* contained in these elements. Independently of the fact that life as such implies a process of material diversification—for the same being can produce bones, blood, etc.—human inventiveness is such that the ways these products are used vary widely across different societies. Thus, Sigaut's chart provides a useful analytic tool for comparison. It would be interesting to expand on this tool to integrate more life forms, including micro-organisms.

A further advantage of using the concept of product is that it connects the vital processes that produce elements such as fat, muscle, hair, blood, etc. in living beings with the technical and economic processes that insert these material elements—which Marx called 'lines of production'—into systems of exchange, giving them a value that in turn depends on the 'process of capital'. We can then articulate three types of processes—vital, technical, and economic—in order to understand how localized agentive configurations, in which various human and non-human agents act, are connected to larger dynamics tying life to work and to capital. In order to understand the imbrications of these multi-tiered processes, we must go beyond a mere inventory of the array of products living beings can provide, and study the multiplicity of interactions that take place between life forms in a given environment. In *The life of cheese* (2013), Heather Paxson does just that, developing the concept of 'ecologies of production' in order to study the intertwined agencies involved in cheese production. She writes that 'artisanal cheese may be made largely by hand, but humans do not make it alone: ruminant animals, herding and guard dogs, and bacteria, yeast, and molds also contribute'. She proposes treating such configurations as 'working landscapes', noting that:

> In a working landscape, grazing livestock are seen to 'work' with human agents to produce value […] [P]roducers direct attention to how various forms of labor and life—from grazing animals to metabolizing microorganisms to skilled humans—come together on a farm to generate the particular qualities of a cheese […] The biological activity of sheep and microorganisms, no less than the industry of humans, can be narrated as producing commodity value because the story taps into wider cultural values regarding the virtue of hard work. (2013: 32–3)

Like Sigaut, Paxson discusses the agencies of various living beings within a common framework, while showing how bioproducts are themselves integrated into processes of production. Her analysis demonstrates that the activity of the living can be understood through the category of work, as the activity of living beings is integrated into a social division of labor and a system of exchanges, ultimately contributing to the creation of capital: 'Milk is also rhetorically produced as good when biological processes of animal gestation, birthing, eating, rumination, digestion, and lactation are narrated *as labor*, since labor (in this theory) is what produces value' (Paxson 2013: 39–40, emphasis original). Instead of Sigaut's two-column table (living being/product), the concept of 'ecologies of production' refers to a dynamic analytic model that can account for the complex, layered connections between vital processes and the systems that organize work and capital:

> By situating artisan cheesemaking within ecologies of production I mean to call attention to the multiple agencies that contribute to agricultural enterprise, while also emphasizing that the dynamic capacities of a farm are harnessed through a capitalist mode of production to generate food for commercial trading as well as for eating. (Paxson 2013: 32)

To understand local 'ecologies of production' from a global perspective, Paxson has created the concept of 'microbiopolitics'. Microbiopolitics refers to the objective and transverse norms and measures that political authorities establish to standardize the production of micro-organisms, such as rules for cheese pasteurization or mandates on the legal length of fermentation.

Such consideration of the multi-scale processes of inter-species collaborations also leads to taking into account the way agentive configurations evolve. Indeed, changes in the relations among living beings also often lead to transformations of organisms, particularly when they are the result of human projects. In his introduction to the work *Industrializing organisms* (Schrepfer & Scranton 2004), Edmund Russell explains that rather than opposing the development of mechanical techniques to the use of animals, we can think of 'industrialisation [as] a biological as well as a mechanical process. Machines, plants, and animals coexisted, industrialization needed living organisms to succeed'. He outlines an 'evolutionary history' that brings data from biology and history into dialogue with one another. Furthermore, he recommends studying how, on account of the plasticity of organisms, 'people have shaped [them] to serve human ends' (Russell 2004: 2). Humans impact the evolution of species—that is, dynamics such as variation, selection, or heritage—by using old methods (introducing a population to a new environment, selecting progenitors, etc.) or very modern ones (gene insertion). Russell calls for a history of techniques that does not focus only on

'human–machine' interactions but also on 'human–machine–nature interactions' (4).

In her piece in *Making and growing* (Hallam & Ingold 2014), historian Jacqueline Field provides a wonderful demonstration of the importance of taking this sort of multi-factor approach in her exploration of silk production, which consists of an intertwining of various vital processes, themselves part of various technical processes.[1] In hybrid communities, where women carry 'silkworm eggs' in their clothing, 'people, plants and insects are intimately interconnected in the labor-intensive silk production process' (Field 2014: 27). This division of labor is anything but static, and it evolves over time—or rather, it causes organisms to evolve, since the silkworms, which can be described as living artifacts, over the course of generations become unable to survive without human care. The author emphasizes, moreover, that this guided evolution, which at the beginning used artisanal techniques, nowadays uses new technologies: 'Transgenic breeding and other manipulations have made new kinds of silkworms. Through bioengineering practices, making becomes an integral aspect of growing' (Field 2014: 40). There are two things to note here. First, investigations into the diversity of techniques used to act upon the living must remember that innovations do not necessarily transform agentive configurations. Instead, they may make it possible to expand on already old practices by amplifying their effects. Second, we must not let examples of guided evolution make us think that humans have always intervened in vital processes as masters and possessors of nature. As Russell reminds us, evolutionary history must take into account evolutions that take place in environments independently of human intentions—a point I will return to in my conclusion.

The Biomedical Mode of Reproduction (Thompson)

By looking at ecologies of production alongside the evolution of organisms, we arrive at an approach that, using a matrix defined by the conceptual pairs production/reproduction and work/capital, is well suited to thinking about biotechnologies. Within feminist critique in particular, biotechnologies have begun to reconsider the production/reproduction distinction established by the Marxist tradition, foregrounding the importance of reproduction in the capitalist process. The 'molecularization of life' (Rose 2006), which increased with the development of new biotechnologies at the end of the twentieth century (e.g., genomics, regenerative medicine, grafting) means that it is no longer enough to pay attention

[1] 'One is the agricultural activity of growing mulberry, raising silkworms and reeling silk filament that is marketed as raw silk […] The other involves the use of raw silk and the activity of making useable threads and weaving textiles' (Field 2014: 28).

to how products that come from living beings are used. We must also take into account the potential of these products, especially in reproduction (Franklin & Lock 2003: 8).[2] The exploitation of these products in agriculture and livestock takes on a different meaning as elements of human bodies are used for increasingly diverse purposes. Not only are organs removed and placed in other organisms; in this 'strange harvest' (Sharp 2006), the body is treated as an assemblage of pieces, some of which can be replaced, including by non-human elements (xenograft) or artifacts (prosthesis). The sharp increase in the amount of living tissues that humans are now able to extract, preserve, grow, and reintroduce into new beings creates a new conception of vital processes. Conservation no longer merely suspends the thanatogenic process, creating a state of 'suspended death' (Kowal & Radin 2015). Technological processes also encourage the reproductive potential of selected living fragments, whether human embryos or cells (Cooper 2008: 127).[3]

Quite logically, it is in the domain of medically assisted reproduction that this paradigm change is most clearly observed. In *Making parents* (2005), Charis Thompson defends the idea that the manipulation of reproductive elements (spermatozoids and oocytes) has led to the creation of a 'biomedical mode of reproduction' that, without replacing the capitalist 'mode of production', generates another source of capital. In order to study the changes brought about by 'assisted reproductive technologies (ART)', Thompson creates the concept of 'ontological choreography',[4] which, like Paxson's 'ecologies of production', describes the modalities by which human activities are co-ordinated with other agencies—in this

[2] S. Franklin and M. Lock describe the innovation that led to the emergence of biocapital as follows: it is 'driven by a form of extraction that involves isolating and mobilizing the primary reproductive agency of specific body parts, particularly cells, in a manner not dissimilar to that by which, as Marx described it, soil plays the "principal" role in agriculture' (2003: 8).

[3] Melinda Cooper summarizes the situation as follows: 'This is where regenerative medicine is strikingly different. If organ transplant medicine needs to maintain life in a state of suspended animation, regenerative medicine, it might be argued, is more interested in capturing life in a state of perpetual self-transformation. Life, as mobilized by regenerative medicine, is always in surplus of itself. This is not to argue, of course, that regenerative medicine dispenses with the methods of tissue and organ preservation—such methods are essential once a tissue construct has been created—but what it works with is the body's capacity to elude such moments of suspended animation and frozen form' (2008: 127).

[4] 'The term ontological choreography refers to the dynamic coordination of the technical, scientific, kinship, gender, emotional, legal, political, and financial aspects of ART clinics. What might appear to be an undifferentiated hybrid mess is actually a deftly balanced coming together of things that are generally considered parts of different ontological orders (part of nature, part of the self, part of society). These elements have to be coordinated in highly staged ways so as to get on with the task at hand: producing parents, children, and everything that is needed for their recognition as such' (Thompson 2005: 8).

case, the agency of reproductive materials.[5] We discover that, just as in Amazonian societies, the human person can be understood as a hybrid, the result of a cross between technical processes and vital processes. It is especially remarkable that in these configurations, living fragments are no longer merely products arriving at the end of a living chain of production and inserted into economic and technical processes. Instead, because of their ability to reproduce and to give birth to new beings, they themselves open new cycles. Thus, another economic system emerges, one that connects work and capital in an entirely new way. Thompson concludes that 'the biomedical mode of reproduction that I trace through the human embryo has its own characteristic systems of exchange and value, notions of the life course, epistemic norms, hegemonic political forms, security, and hierarchies and definitions of commodities and personhood' (2005: 248).

Along similar lines, in a paper published in 2009, Pálsson, starting from a synthesis of works dedicated to the social consequences of biotechnologies, proposes the expression 'biosocial relations of production' (a phrase also used in the title of the paper) to define the new configurations to which these technologies give rise. He writes that: 'Life itself is increasingly modified and reproduced through artificial means, including cloning, genetic engineering, and synthetic biology' (2009: 293). As a result, the Marxian approach to the economy can be extended to 'biosocial relations of production', highlighting the 'hierarchies and materialities of the political economy of the fragmented, manufactured body' (2009: 296).

In *The pasteurization of France* (1993), and in particular in his essay 'Irreductions' (part II), which follows that text, Bruno Latour mobilizes the notions of actant, agency, and network to achieve a non-anthropocentric description of the real and to grasp the simultaneously natural and social dimension of microbes. Despite the undeniable heuristic advantages of the actor-network theory, the problem is that it tends to 'flatten' the world. The risk is that the notion of agency will be used as an all-encompassing category, without taking into account the specificity of vital processes. In my opinion, it is more promising to retain what is specific about the agencies of life and the living, and thus to highlight the specific capacities for (re)production these agencies add to a network.[6] This is why

[5] 'Ontological choreography coordinates two different ''things'' that are especially salient in ARTs—the grafting of parts and the calibrating of time. An important element of ARTs is the grafting of the properties and processes that make up a thing onto the properties and processes of another thing. Thus, when body parts and instruments are mixed up to make a woman pregnant, the properties and processes of the instruments are annexed to the body parts in a way that makes a pregnancy become possible' (Thompson 2005: 9). On this issue, see also Mol's 'forms of coordination' in *The body multiple* (2002).

[6] But see Latour's analysis of the concept of lineage in Latour (2012).

Pálsson's proposition seems perfect for deepening the Latourian model. As Pálsson writes, 'The *bio-graphies* of fragmented bodies, in the literal sense, their life-courses, unfold through the agency of a series of actors and actants, in the Latourian sense, who both constitute and are constituted by particular biosocial relations of production' (2009: 302, emphasis original).

Thus, the goal becomes tracing the singularity of the organization of technical and vital processes in a universe where living fragments seem to be increasingly autonomous and break away from organisms to themselves become (re)producers. It is not just the preservation of elements such as blood or organs which is at stake, but the potentiality of bioproducts to produce new products and, consequently, new sources of wealth. In this context, the potential of biological development implies also economic potentialities. Independently of ART, cell culture and the re-programming of stem cells contribute to reshaping how human actions are co-ordinated with the agencies of these fragments. In *Life as a surplus* (2008), Melinda Cooper summarizes the situation nicely:

> Regenerative medicine needs to cultivate the process of embryogenesis in such a way that it maintains its full spectrum of transformative possibilities. It requires a state of embryonic being that never grows up into this or that particular organism: a process of *self-perpetuating, unactualized, and unfinishable embryogenesis*. This is quite literally what biologists are attempting to accomplish when they culture and 'immortalize' an embryonic stem cell line. (2008: 127, emphasis original)

Here again, the challenge is to reinterpret the agency specific to the living in terms of 'work' or 'labor', or as the title of an article that Cooper co-authored with Catherine Waldby puts it, 'From reproductive work to regenerative labor: the female body and the stem cell industries' (2010). The possibility of 'culturing life', to use Landecker's expression (2007), does more than transform the conditions of production: it also changes systems of values.

As early as 2008, Helmreich proposed a summary of works in the social sciences dedicated to the capitalist development corresponding to the value attached to the reproductive capacities of the living. Beyond the commodification of products or parts of the human body (Scheper-Hughes & Wacquant 2002), it is a question of their capacity to engender new forms of wealth. According to Cooper, there is thus an overlap between reproductive medicine and neo-liberalism: both have the ability to continuously generate surplus. This capitalist logic does not only apply to the human body, but also to the natural resources exploited in 'bioprospecting' (see Hayden 2003). Waldby and Robert Mitchell point out, however, that the proliferation of tissues that are preserved and circulated in complex systems of exchange cannot be reduced to the dynamic of commodification, nor even to the dichotomy between gift and economic exchange

(2006: 6). Kaushik Sunder Rajan reveals how the process of biocapital and the fluidity of wealth creation owe a great deal to the new dialectic between materiality and the abstraction of the living. He writes that:

> The difference now is that genomics allows the *metaphor* of life-as-information to become *material* reality that can be commodified. In other words, one does not just have to *conceive* of life as information: one can now *represent* life in informational terms that can be packaged, turned into a commodity, and sold as a database. (Sunder Rajan 2006: 15, emphasis original)

Engineering the Living: Assemblages and Systems

Humans have long shaped and disassembled living beings in order to extract various products from them; from a certain point of view, the development of biotechnology merely continues this trend by manipulating reproductive materials. However, as advances continue in this domain, we are right to wonder whether biotechnologies represent a change in nature rather than in degree. Thus, François Dagognet declares: 'previously, humans worked on masses, polishing, scraping, dividing […] altering forms. Today, we touch substance. In other words, biotechnology is noumenological whereas traditional technology is phenomenalist' (1990: 114). This is especially true now that human efforts go beyond disassembling the living and strive to reassemble and synthesize, something that the world of the imagination has long explored, for instance, in the narratives of the Golem or Frankenstein, which inquire into how an organism can be built and animated through technical assemblage. Metaphors that treat life as text or as a program lead to the idea—if only as a logical complement—that analytic operations lead to a recombination. This is understood as a re-writing or a re-programming, so that the idea of 'making an organism' (Keller 2002) is no longer unrealistic. The trend toward decoupling the materiality of vital processes from the more abstract treatment of information (Landecker 2007; Sunder Rajan 2006) changes the nature of interventions on the living, which come nearer and nearer to engineering, whether it is a matter of 'tissue engineering' (Waldby & Mitchell 2006) or cloning (Franklin 2007). But the trend is most manifest in synthetic biology. While Systems Biology uncovers the elements involved in vital processes, recent advances in synthetic biology suggest that in time it will be possible to make new living forms, just as synthetic chemistry has been able to create new chemical forms.

Even if it is necessary to rigorously take many variables into account in order to correctly identify which are true innovations, as well as to distinguish between media discourse and the reality of advances and potentials, it appears that after the explorations of precursors such as Leduc and Loeb in the twentieth century

(Keller 2002), synthetic biology has reached a new stage. In determining the place of synthetic biology in the history of biology (Morange 2009), we must look at interdisciplinary collaborations in particular (Molyneux-Hodgson & Meyer 2009; Rabinow & Bennett 2012), in a domain that is anything but homogeneous, with its diversity of techniques, scales, and modalities of intervening on the living. Thus, Christophe Malaterre (2009) proposes distinguishing three types of synthetic biology: 'engineering of genetic circuits, of entire genomes, or of organisms'. Anna Deplazes-Zemp (2012) distinguishes five approaches: bioengineering, in silico synthetic biology, synthetic genomics, protocell synthetic biology, and unnatural molecular biology. Toepfer (2016) lists eight types of artificialities grouped into two categories depending on whether the elements combined by a synthesis are living or not. I will not delve into these discussions, which would lead me far from my subject, but rather will review the (well-known) reasons why we refer to the category of engineering in the domain of synthetic biology.

It is perhaps in the presentation of this field by MIT researchers working with Drew Endy (2005) that we can most clearly see the desire to create a relationship to the living that depends less on investigating vital processes and more on developing technical procedures that can compose their fragments. Through a triple operation of 'standardization, decoupling, and abstraction', their goal is to create a stock of 'BioBricks' for manipulating vital processes. BioBrick parts are DNA sequences that conform to a restriction-enzyme assembly standard. These building blocks are used to design and assemble larger synthetic biological circuits from individual parts and combinations of parts with defined functions, which would then be incorporated into living cells such as Escherichia coli cells to construct new biological systems. Examples of BioBrick parts include promoters, ribosomal binding sites (RBS), coding sequences, and terminators.

This approach sees the manipulation of BioBricks as analogous to the creation of electronic circuits and information programming. It considers that in order to function, an assemblage needs to bring together different elements (parts, devices, and systems) according to hierarchical principles. Whereas the 'biomedical mode of reproduction' emphasizes the potential for reproducing biomaterials, synthetic biology announces a more standardized type of intervention, in which fragments become 'tools' (see Deplazes-Zemp 2012). BioBricks convey a dual conception of the living because they are materially conserved in refrigerators and can also circulate and be distributed like software programs that non-specialists can use. This desire to open the field of technologies of the living to non-scientists can be seen in the annual IGEM competition, in which interdisciplinary teams present projects (in ecology, medicine, etc.) that could benefit from using synthetic biology. The organizers of this conference defend a peer-to-peer sharing economy, in which

participants have to use the BioBricks made available by the community, while also sharing those they have developed themselves. However, we may note that this ideal is not inherent in synthetic biology. Another well-known figure in this domain, Craig Venter, represents a clearly more mercantile modality, with an approach that sometimes has thaumaturgic overtones.

It is remarkable that, no matter which economic models the actors working in synthetic biology choose and what the actual results obtained may be, the question of making holds a central place in thought and discourse surrounding this practice. In 'How a "drive to make" shapes synthetic biology' (2013), Pablo Schyfter explains that the goal of synthetic biology, which is to 'make things' rather than to produce knowledge as pure sciences do, has organizational, methodological, epistemological, and ontological consequences. The ontological implications allow us to grasp the specificity of the underlying conceptions of life: 'the things of living nature are constituted as ontologically equivalent to the inanimate materials employed by existing engineering fields: as usable substrates at the disposal of technology-making ventures' (2013: 4). That, however, does not mean we should understand this conceptual change as a reduction or homogenization, for the term 'making' refers not to a uniform activity but to a diversity of practices and methods. Schyfter specifies:

> The field's internal divisions come not from divergent commitments to making, but rather from different uses to which that making is put and competing methods by which it is carried out. Paradoxically, making becomes both what defines synthetic biology's boundaries and a ground for internal contests. (6)

He therefore suggests that 'making'[7] and 'engineering' should not be treated as synonyms, since making refers to a wider range of actions than engineering in the strict sense. Drawing on the discussion begun by authors such as Evelyn Fox Keller (2002, 2009), Maureen A. O'Malley et al. (2008), and Sophia Roosth (2013), Schyfter proposes complicating our understanding of the articulation between making and knowing. He distinguishes 'making to know' from 'knowing to make': 'Each of these relationships is characterized by different end goals, types of construction and epistemic species' (2013: 10).

Consequently, the study of 'life as a making' must highlight the existing differences *between* various fields of practice as well as the heterogeneity within each of these fields. Although engineering pursues an ideal of standardization and

[7] 'I employ the term "making" in its ordinary sense. That is, I understand making to be broadly synonymous with creating, constructing, building and producing: it is the putting together, bringing-into-material-existence of something. The plainness of this definition does little to convey the richness of its consequences for science and technology. Fields seeking to construct things differ in significant ways from those intent on other ends, such as developing knowledge claims and furthering understanding' (Schyfter 2013: 2).

uniformization, like any technical activity, it functions only because of the constant combination of heterogeneous elements and actions. This is why we must not have too narrow a view of engineering; we must take into account the fact that along with acting on living beings or on fragments of them, engineering projects also aim to create artificial beings or environments. Although these do not display biological characteristics, they can be considered living if we understand life as the process of creating a relational system between beings.

It is interesting to examine how the decomposition/recomposition pair operates in domains other than biotechnology—for example, in the fields of artificial life and robotics. It may seem surprising to compare these spheres of practices in which actions take place on the 'real stuff' of the living. Nevertheless, the works of Sherry Turkle (2011) and Dominique Lestel's piece (2017) in this special issue demonstrate how interactions with artifacts, whether robotic individuals or artificial environments, are central to our way of existence. New technologies, even if they are not biotechnologies in the strict sense, thus participate in redefining the living, both through their efforts to imitate it and in the ways they deeply transform what it is to live.

In *Creation: life and how to make it* (2003), Steve Grand recounts the development of *Creatures*, a game in which players create beings that develop within a digital environment, thus popularizing the idea that artificial life can replicate certain vital processes outside of organisms. Helmreich's fascinating study *Silicon second nature* (1998) traces the specificity of these technologies that approach the question of the living not through the materiality of the phenomenon but rather through its capacity for self-organization. For experts in artificial life, the algorithms that cause forms to develop and 'self-reproduce' in artificial environments cast light on biological traits that can be imitated. The existence of this particular kind of life-form leads some to imagine, following Christopher Laughton, an entirely new way of doing biology: 'They hope the creation of such life-forms can expand biology's purview to include not just *life-as-we-know-it* but also *life-as-it-could-be*—life as it might exist in other materials or elsewhere in the universe' (1998: 8). In this context, the contribution of an anthropological investigation would be to show that 'Artificial Life scientists' computational models of "possible biologies" are powerfully inflected by their cultural conceptions' (Helmreich 1998: 11). Thus there are not parallel universes but rather an essential connection between the virtual and the real (or the digital and the real), one that ought to be analyzed to open a space for contextualizing and comparing understandings of the living. But above all, as in artisanal activity, there is a co-dependence between techniques for intervening on the living—in the present example, the programming that causes artificial life-forms to emerge—and the

epistemological categories created to think about the phenomenon of life. Helmreich states:

> An object or process like 'life' does not exist 'out there', waiting for us to name it […] This book, though centered on the human agencies enlisted in the making of Artificial Life, tries to get at how new notions of life are being materialized, specifically, at how life is being crafted to inhabit both the natural and the artificial—a process that is already transforming our meanings of nature, evolution, and life. (1998: 22)

Though it is possible to see artificial life as an imitation, the most stimulating theoretical objective consists in going beyond the living being/artifact dichotomy and categorizing the diverse modes of connection between conceptual development and the creation of artifacts.

The same is true in the domain of robotics, which attempts to create animate artifacts that have cognitive and physical functions similar to those of living beings. In *Humanoïdes: Expérimentations croisées entre sciences et art* (2015), Joffrey Becker portrays the creations of such artifacts by using a model of the living that is broken down into its functional elements and then (re)assembled. Analyses of physical movements and perceptive abilities must be translated into a programming language and a mechanical layout to ensure the robots have relative autonomy. The imitation of life goes beyond the materiality of bodies and involves a team effort to reproduce cognitive operations in robots. The hardware/software dichotomy appears as an ultimate variation of the opposition between a body engaged in physical movements and a mind tasked with handling information. Thus, there is imitation not just of organisms but also of the capacity to model ecosystems. The objective here is to create the most sophisticated loops possible between perception and reaction so that robots will succeed in moving and interacting fluidly in an environment.

Digital artificial life creates an interactive and evolving dynamic that encourages the diversification of life forms within a relatively uniform universe that depends on a common programming language. On the other hand, in robotics, the challenge is to integrate the dissimilar and the heterogeneous in ways that lead to the emergence of quasi-persons (Dufrène, Grimaud, Taylor-Descola & Vidal 2016). Along the same lines, Becker follows the works of Grimaud and Vidal by highlighting the human tendency to attribute intentionality to even the most rudimentary artifacts. For the moment, the rigidity of human creations still seems to sharply demarcate them from biological beings, which are precisely characterized by their ability to combine the rigidity of certain parts with the elasticity of others. In sum, it is the 'tensegrity' specific to life that human technologies still have not managed to create, even though ever-finer integration of physical mechanics,

cognitive operations, and processes remains a goal. From a certain point of view, humans' intentions here remain similar to those that led to the invention of the 'defecating duck' by Vaucanson, who was also trying to create a living mechanism. In her analysis of this invention and, more broadly, of human attempts to imitate the living, Jessica Riskin (2003) demonstrates a sort of oscillation in human thought regarding such enterprises. She notes that through the ages, any progress made toward better knowledge of life, and thus toward a better imitation of it, has always been accompanied by the observation that humans are powerless in the face of the complexity of the phenomenon of life, which is ultimately acknowledged to be inimitable.

It is possible that (bio)technical innovations are in the process of refuting this persistent observation. In any case, that is what certain discourses of bio-engineering of the living seem to promise, in particular, in order to affirm that various technologies are now converging. Indeed, it is not far-fetched to imagine an intersection between engineering, which manipulates vital processes in an attempt to recombine biological elements at a microscopic level (here we may think of the possibilities contained in CRISPR/Cas9), and robotics, which imitates these processes at a more human scale. Whether we are thinking of micro-robots inserted into bodies to help with physiological functions, or of living elements being inserted into artifacts, it is clear that these intersections are many and lie at many levels. This is certainly the case when we consider that information technology is an increasingly effective interface for acting on the living. That is why, as Casper Bruun Jensen and Anders Blok (2013) suggest in their work on 'techno-animism' in Japan, we must develop an ecological approach. In addition to thinking of life as a multi-scale process, this approach should try to retrace the ontologies specific to certain cultures in order to detect how they understand relations between living beings and artifacts. Obviously, the future will tell how far the convergence between technique and ontological domains will go, and it will offer keys for evaluating which techniques can actually be put into practice. My goal is not to decide on this matter, but rather to show how the diversification of human technical activity causes new paradigms to emerge for thinking about and acting on the living. The fields of engineering I have discussed are all based on breaking down vital processes into material and informational elements, in order to perform a synthesis and attempt to create individuals or environments. However, this ideal of making corresponds to a diversity of practices and thus to a wide array of conceptions of the living. Serious study is required of the problems it raises, which cannot be solved by the dichotomy between living and artificial alone. Furthermore, the socio-economic systems in which these techniques flourish also vary greatly, so that we must look beyond the connections between biotechnology and capitalism

and take alternative positions into account. Whether in the domain of bioart or do-it-yourself biology, we find practices that use technologies—sometimes the newest ones—and simultaneously hack them or call them into question. This, by the way, proves that a technique cannot be characterized solely on the basis of material procedures: the goals of those who practice it are also part of its identity. Now that we have seen how the engineering model tries to appropriate the efficacy of biotechnologies, I would like to look at a few attempts that contest this model: those of the artist and those of the tinkerer or *bricoleur*.

Bioart and Tinkering [*Bricolage*]: From Poetics to Politics[8]

The increase and diversification in forms of human mastery over the living raise serious questions, for they profoundly reshape many parts of existence. The appearance of new life forms requires us to rethink how agriculture, livestock raising, reproduction, and medicine, for example, are practiced and understood—in particular in order to invent adequate social relations to adapt to these innovations. As Helmreich writes:

> the relation between life forms and forms of life has become liquid, turbulent […] Like the gene [...] life is being redistributed into a fluid set of relations. Life is strange, pushed into its conceptual limits, spilling across scales and substrates, becoming other, even alien to itself. (2009: 8)

In order to handle the ethical, political, and economic problems raised by advances in biotechnologies, many countries have created committees of experts to set frameworks for research or to assign objectives to it. Indeed, it is necessary to deliberate not only on the design that presides over the making of an object—or bio-object—but also on the possible uses that might be made of it, including ones that should be forbidden. In short, it is necessary to evaluate a technique not only with respect to its purposes but also to the goals that societies decide to pursue. In parallel to this kind of framing, which takes place by deepening our knowledge of the potential of biotechnologies, whether positive or negative, bioart and do-it-yourself biology contribute to this collective reflection, though in a different register. In both domains, making and human inventiveness are highlighted and on display. One of the objectives is to maximize awareness of the radical changes and possible dangers that result from biotechnological innovations. This opening to the public takes place through dialogue performed by exhibitions and sometimes through confrontation with the sciences and practices of individuals, who themselves become makers or hackers capable of acting on vital processes in their

[8] This expression is used by Morgan Meyer (2014) in the title of the piece, 'Hacking life? The politics and poetics of DIY biology'.

bodies or environments. Bioart sheds particular light on certain characteristics of the living, to which I will now turn.

It is common to distinguish between art and technique by saying that the former has a less utilitarian relationship to creation. However, bioart's use of various biotechnologies—both old and new—to act on the living justifies its inclusion in the present discussion. In *Green light: toward an art of evolution* (2010), bioartist George Gessert reminds us that acting on living organisms for aesthetic ends is nothing new—as attested by the creation of species of companion animals or the development of ornamental flower art. He writes, 'In the light of biotech art, many domesticates can be understood as bio folk art' (xx). The effectiveness of these configurations is based on the semiotic dynamic of living beings, who both perceive and are perceived. Thus, Eduardo Kohn (2013: 75) declares that 'life is a sign process', by which he means that each living being adapts to the signs emitted by other living beings, as well as to the way in which itself is perceived, and that these habits are transmitted from generation to generation. Without necessarily following him as far as this last point, which remains highly speculative, we may agree that the diversity of life forms that populate the world appear in the multitude of sounds, colors, images, flavors, and textures that are associated with them. Whether in hunting (Ingold 2000), fishing (Sautchuk 2012), or agricultural and horticultural activities (Malinowski 1935), it is clear that every human technique involving the living includes—at a minimum—a semiotic dynamic, and even an aesthetic evaluation. In the plant and animal worlds, the combination of these signs is one of the principle means by which beings interact. The ability of certain animals to modulate their songs and colors or to utilize elements of their environment to make objects—for example, in the nuptial parades of certain birds—even suggests that there are bodily and material animal techniques that allow these beings to influence their environment. Jean-Louis Schaeffer (2007) even proposes seeing these practices as the matrix out of which human aesthetic activity emerges.

In parallel with artistic practices that involve working on inert materials in order to create a perceptible effect—and even to imitate living beings—humans have long developed aesthetic practices that incorporate vital processes. Outside of the living arts (dance, singing, and theatre), which, in fact, mobilize the body as a means of expression, other life forms may also be used to produce aesthetic satisfaction. It is first and foremost the malleability of vital processes (whether on the level of the individual or that of the lineage) due to selective breeding or cloning that offers humans the pleasure of seeing the effects of their actions on organisms. But the fact that the effects of these processes are somewhat unpredictable also seems to be an attraction. It is as if the pleasing play between

control and uncertainty, between the creator's intention and the development of the work, were reinforced in these configurations precisely by the presence of beings that have their own agency. Finally, in addition to their value as qualisigns, living beings and their fragments may act as signifying elements, as we see in the highly symbolic practice of garden art, for example. In short, by using the semiotic potential of the living, humans play with various aspects of the phenomenon of life: its plasticity, its capacity to evolve and to vary, as well as its connectivity. It is not just the power of formation or shaping of an organism that is at stake but the fact that its fragments can be re-connected to other elements, living or artifactual, in order to create an aesthetic effect or even a narrative or symbolic discourse.

Today, this practice of combining heterogeneous elements, mixing living materials with expressive materials created using more or less ancient techniques (drawing, sculpting, poetry, photography, video, etc.), constitutes one of the characteristic traits of bioart, which has become a domain of its own within the art world. In 1936, the Museum of Modern Art (MoMA) in New York brought living beings into the museum space in the form of the floral composition *Delphiniums*, by Edward Steichen. For the past thirty years, this field has been growing,[9] and works in which artists use cell cultures, genetic programming, or IPS (induced pluripotent cells) are exhibited in some of the world's best museums. Bioart projects, whether connected to university institutions such as the *Symbiotica* lab at the University of Western Australia, led by the artists Oron Catts and Ionat Zurr, to art schools such as Suzanne Anker's *Bio Art Lab* at the New York School of Visual Arts, or to the do-it-yourself biology network, are always based on collaboration between scientists and artists—or at the least, on a commitment to interdisciplinarity. In addition to the plurality of institutional contexts, the variety of technologies used to manipulate the living proves that a work's aesthetic dimension lies less in its technical characteristics and more in the spirit that presides over its creation and in its strong performative value. By bringing new types of beings into existence, artistic processes demonstrate human inventiveness, which is increased by the fact that it often brings out new potentialities in living beings.

In order to grasp the variety of relations with the living in this domain, Gessert created a chart entitled 'Organisms in Bio Art' (2010: Appendix I), which lists the living beings and biomaterials contemporary artists have used in their works—and they total about a hundred. Insects, mammals, plants, fish, trees, grasses, mushrooms, and bacteria: the list of life forms mobilized in these projects seems to grow constantly. This is especially true because acting at the level of genes and cells (human or animals) offers artists—such as Eduardo Kac, Joe Davis,

[9] See, for example, the edited volumes *Signs of life* (Kac 2007) and *Meta-Life* (Bureaud, Malina & Whiteley 2014).

or Gessert himself—unprecedented possibilities for decomposition /recomposition: there seems to be an astonishing, teeming bestiary in which hybrid beings make a mockery of the classic concepts usually used to think about the living. In contrast to engineering, which usually employs problem-solving procedures, art, and *a fortiori* bioart, when successful, creates hitherto unknown objects and relations that raise new problems. This is true of the works created within the framework of the *Tissue Culture and Art Project*. For example, *The Victimless Leather* project grows 'living tissue into a leather-like material'. The work 'is grown from immortalised cell lines which are cultured and form a living layer of tissue supported by a biodegradable polymer matrix in the form of a miniature stitch-less coat-like shape' (The Tissue Culture and Art Project n.d.). These ephemeral living works, whose ontological status is uncertain, along with these 'semi-living' beings, are presented to the public by means of 'extended bodies' and compel us to wonder about the possibility of separating vital processes from organisms. Along similar lines, Guy Ben-Ary's work explores the paths of convergence between living beings and artifacts. This is for instance the case in *Cellf*, an installation that connects a network of neurons obtained from the artist's cells using iPSC technology to a synthesizer that produces sounds and can interact with musicians (2015). Kac's work in the field he has named 'transgenic art' (2016) foregrounds the issue of hybridization and the genetic proximity of kingdoms of living beings, in particular in works such as 'Edunia' (humans/plants) and 'Alba' (rabbit/jellyfish).

The more or less explicit desire to cause surprise and provoke discussion shows that beyond poetics, there is a political aspect to the work of artists who use living beings in their pieces (Meyer 2014). The book *Tactical biopolitics: Art, activisim, and technoscience* by Beatriz da Costa and Kavia Philip (2008) offers a good overview of this aspect. Taking their cue from Michel de Certeau's analysis of means of appropriating and deflecting [*détourner*] the elements of modernity (1984), they show a new aspect of technique. In addition to the material processes (artisanaland biotechnological) that artists use, their *strategies* are also techniques, just as poaching techniques arose in the shadow of hunting techniques. By paying attention to the sociopolitical consequences of biotechnological innovations, the goal is to create spaces for debate or, at the least, alternative paths that encourage critical reflection on emerging practices. This is the goal, for example, of the *Critical Art Ensemble* in developing a 'contestational biology' and 'bioresistance' (see Critical Art Ensemble 2002).

We should not, however, conclude that the critical enterprise seeks only to propose alternative uses for molecular biology. Within the field of bioart, various ways of thinking about the manipulation of the living art are defended or, on the

contrary, criticized, so that debates take place within the field itself in order to prevent one type of technique from appropriating the discourse on the living. Thus, Oron Catts and Ionat Zurr praise 'wet biology': in contrast to the feeling of power that may result from treating life as an informational process in transgenic art, here the emphasis is on the materiality of vital processes and the uncertainty that surrounds them. Thus the authors explain that 'the narratives we would like to question with our "wet hands" are the narratives of life as a coded program—"biology as information"—and the way it serves the ideology and rhetoric of Western society advancing toward a false perception of total control over life and a technologically mediated victimless utopia' (Catts & Zurr 2008: 126).[10] Hence, cell culture appears as an alternative model within a space of contestation that presents the Maker not with the vertigo of a demiurgic power over biomaterials but rather with a more humble reflection on the essential uncertainty that accompanies the manipulation of vital processes. Above all, it implies another way of thinking decomposition and recomposition. Without denying the importance of molecular biology, the authors declare that:

> We would prefer to relate regenerative medicine to fragmenting, mixing, and reconstituting life. For example, fragmenting can be seen as isolating cells or tissues; mixing involves culturing/co-culturing; and reconstitution refers to embodying the result either in a new host body or in a new kind of 'body' or vessel (bioreactor/technoscientific body). (136)

Finally, rather than fetishizing DNA, these authors favor a 'multi-scale' approach that focuses on how vital processes are integrated into various levels of organization, from the cell to the environment by way of the organism.

Clearly, it would be wrong to claim that all bioartists are critical of some or all biotechnologies. A detailed study could catalogue the wide array of discourses developed by artistic creators and the variety of strategies they use, which range from fascinated usage of the potentials unleashed by new materials to frank opposition, for example, to genetically modified organisms (GMOs). Rather than carrying out this analysis, I will pursue my initial cartography of the relationship between technical activities and conceptions of the living by focusing on the domain of 'do-it-yourself biology', where both critical approaches and alternative scenarios are put forward. While engineering defends an ideal of mastery and

[10] 'As some of the current major developments in the life sciences are concerned with cell development (rather than only genetics), it is worthwhile to look at cell theory and tissue culture at the beginning of the twentieth century. These theories are concerned with the materiality of 'life' and the environment in which it is grown. Rather than on code, there is an emphasis on communal interrelationships as a reference point' (Catts & Zurr 2008: 137). 'Working in laboratories with living materials, we were faced with the complexity of life in its multi-levels. How living entities (whether genes, cells, organs, organisms, or populations) cannot be separated from their environmental factors, and are always in flux' (138).

efficiency—an object's purpose should determine the means used to make it—the celebration of human inventiveness and bricolage generally seems to go along with respect for, or at least vigilant attention toward, that which in the living constitutes a type of autonomy that resists total comprehension and mastery [*arraisonnement*].

As the name suggests, do-it-yourself biology promotes a relationship to the living by non-scientists who appropriate the techniques usually reserved for professional scientists (Landrain, Meyer, Perez & Sussan 2013; Roosth 2010) for a wide variety of projects that attest to the hodgepodge of principles and plans that make up this domain. As Morgan Meyer (2012a, 2012b) tells us, the experiments performed may involve the authors extracting their own DNA and testing for genetic diseases or devising tests to determine the provenance of certain food items, or, more playfully, finding ways to produce fluorescent yogurt. Meyer uses the notion of tinkering (*bricolage*) to describe this diversity; the concept illuminates several aspects of DIYbio. The diversity of projects is linked to a process that gives more room to free exploration and to the simple pleasures of experimenting, doing, trying than engineering does. In 'DIYbio: Making things and making futures', Anna Delgado (2013) states that one of the characteristic traits of DIYbio is that it 'produces things rather than techno-objects' (65). Specifying that 'tinkering is learning by doing', she adds that 'DIYbio hackers appear as "bricoleurs" in the sense of Lévi-Strauss: assembling heterogeneous elements together, but not necessarily following a strict plan or a method' (69). Bricolage also involves making objects to manipulate the living. Here too, inventiveness is the rule and objects are diverted [*détourné*] from their initial functions (for example, a PCR is created using a drill). Meyer declares that 'The *mutability* of objects is also extremely important. Ordinary objects and modest resources can be transformed into scientific tools' (2012a: 319). Alongside this engagement with material, which promotes an individual, concrete, and active relationship to biomaterials as well as to the tools used to act on them, DIYbio also implies a special relationship to knowledge. As with biocapital, DIYbio is based on a kind of decoupling of materiality and information. However, it is used in radically different ways for very different ends. The Biohacking movement (Delfanti 2013) defends the values of transfers and open science.

The valorization of tinkering goes further than simply promoting know-how and knowledge sharing: it is connected to an original understanding of the living. While sharing with craftsmanship and engineering the idea that living beings and vital processes can be thought of as assemblages of elements that can be re-composed, bricolage introduces a critical distance from the notions of function and finality. The inventiveness that goes into bricolage is such that similar functions can be obtained with different objects while, conversely, a single object may have

various functions, so much so that a pre-existing design or goal for fabricating an object is not essential to technical processes. This is an especially interesting point because bricolage is not merely a way of acting on the living, as the other techniques discussed in this article are: it is also a metaphor for thinking certain characteristics of the vital process as such. Thus, in *Evolution and tinkering* (1977), François Jacob explains how, from a certain point of view, the evolution of living beings can be conceptualized by analogy with this human practice. After having reminded readers that the results of evolution are far from perfect—as the extinction of hundreds of millions of species proves—Jacob suggests that:

> [tinkering] has several aspects in common with the process of evolution. Often, without a well-defined project, the tinkerer gives his materials unexpected functions to produce a new object […] Similarly evolution makes a wing from a leg or a part of an ear from a piece of jaw. Naturally, this takes a long time. Evolution behaves like a tinkerer who, during eons upon eons, would slowly modify his work. (1977: 1164)

Many examples of this process can be found in the animal world. For example, take the development of lungs out of the esophagus among vertebrates; 'to make a lung with a piece of esophagus sounds very much like tinkering', Jacob notes (1164). This example leads him to distinguish between tinkering and engineering: 'Unlike engineers, tinkerers who tackle the same problem are likely to end up with different solutions' (1164; see also Bardini 2011). We see this in the fact that eyes, which have appeared many times over the course of evolution, perform the function of photoreception using very different principles: pinholes, lenses, and multiple tubes. Jacob thus concludes, 'Evolution does not produce novelties from scratch. It works on what already exists, either transforming a system to give it new functions or combining several systems to produce a more elaborate one' (Jacob 1977: 1164).

Conclusion: Technical Activity and the Ecology of Living Systems

There is always some danger in using human analogies to conceptualize natural phenomena, as we see in the use of the idea of design by those who oppose evolutionary theories. In certain respects, mobilizing the figure of the tinkerer also risks anthropomorphizing vital processes. In actuality, things are more subtle, precisely because the absence of design for transforming beings through the composition of elements yields an immanent conceptualization. Life appears as a making that produces its effects without us having to hypothesize an intention or a plan that would organize a variety of processes over the extremely long term. Understood this way, connecting technique and life opens up onto another understanding of the real, within which the place of humans varies. It is true that in

most cases the technicist metaphor that understands life as technique tends to foreground scenarios in which human activity—or the activity of demiurges acting like humans—constitutes a referent for interpreting vital processes. But with the hypothesis of 'evolutionary tinkering' the order of relations is reversed, and human technique is seen as an extension of vital activity. This does not only mean that very similar morphogenetic dynamics lead to the hypothesis of continuity or co-evolution between living beings and artifacts, as Ingold's phenomenology (2011) and André Leroi-Gourhan's materialist theories (1943) suggest. It also means that life *as such* is a process of decomposition and recomposition that allows heterogeneous elements to be assembled into extremely diverse configurations that evolve over time, without any pre-existing order of implementation organizing a sequential chain.

Thus, by maintaining that it is relevant to describe the 'agentive configurations' within which vital processes appear, I wish to emphasize the fact that in most cases it is instructive to describe in a single movement the actions of humans on living beings, the agency specific to these beings, and the modes of their co-ordination. However, this approach, with its emphasis on human practices and intentions, must not obscure the fact that at the same time all the non-human living beings also act on their environment as well as on humans. To be complete, an approach that sees life 'as a making' must therefore also attend to the ecological dimension of life in order to trace the dynamics at work *independent* of human activity and even, by reversing the order of causality, those that act on humans. Doing so is one of Ingold's and Pálsson's goals when they call for the development of an anthropology that can study 'biosocial becomings' (2013; see also Pitrou 2015b). Ingold's understanding of evolution seeks to reconceptualize the relation of organisms to their environment, a zone of interpenetration: 'Within this zone, organisms grow to take on the form they do, incorporating into themselves the lifelines of other organisms as they do so. Every organism is a site of infestation, a vast ecosystem in itself' (2013: 11). Against the idea of design, Ingold emphasizes the interactions between beings. Thus, human beings can be thought 'in terms not of what they *are* but what they *do*' (2013: 8, italics in original). But this does not mean that humans have a central position, as emphasized in Pálsson's remarks concerning the concept of 'milieu' in Canguilhem: 'The focus on milieu does not mean that the living organism has disappeared from sight, devoid of agency: on the contrary, the organism is the radiating center of pragmatic activity' (qtd. in Ingold 2013: 27). Similarly, in her chapter 'Life-in-the-making: Epigenesis, biocultural environments and human becomings', Eugenia Ramírez-Goicoechea emphasizes the importance of 'action-in-relationality' and reminds us how advances in epigenetics have led to the abandonment of the unilateral determinism sometimes

expressed in discussions of genes: 'Gene-centered biology and its related disciplines do not consider the organism (or any other unit) as a co-building agent of its surroundings but rather as a passive recipient of evolutionary forces' (2013: 69). In contrast, 'the concept of niche construction captures this complex autopoietic process of action in evolution' (71).

Stating that anthropology benefits from treating 'life as a making' thus does not mean privileging an anthropocentric approach that would see in old and new biotechnologies the mark of the human ability to extract themselves from biological laws. The growth of biotechnology is stupefying and certain promises for the future provide glimpses of radical breaks—for example, not merely domesticating the living but fabricating it 'from scratch'. However, it is also possible to put technical activity into a broader framework, by taking into account the fact that life as such did not wait for humans before carrying out operations of combination and shaping that take place at multiple levels. Even if the growing variety and efficacy of human techniques does assuredly constitute something new within evolutionary tinkering, we must also note that such a movement did not come out of nowhere and that in many respects, all living beings make their environments (see Latour's analysis (2015) of Lovelock's and Margullis's theories). In short, approaching life as a making only makes sense if human agency is understood in relation to non-human agency. It was precisely in order to carry out this descriptive and analytic project that I created the conception of 'agentive configuration'. Although in most cases it is used to examine how human actions are carried out to control or influence living beings, it can also be used to study how other living beingscontinuously participate in constructing environments—including within themselves—and setting the co-ordinates of human existence.

My goal in this article has been to begin to explore the diversity of techniques that humans have developed to act on the living, as well as to understand the specific characteristics of the vital processes associated with this diversity. The domains of crafting, modes of (re)production, selective breeding, technology, engineering, tinkering, and art all represent agentive configurations that involve specific relations to the living. In truth, this is above all a heuristic and methodological distinction. In fact, it seems that these domains themselves refer to very heterogeneous techniques, while similar techniques are sometimes used in very different projects. In any case, certain techniques—cognitive techniques, techniques of the body—seem to be present in all these domains. The goal of studying this matter will be to propose a systematic articulation of these interplays of difference and similarity. To carry out such an undertaking, the anthropology of life can only obtain convincing results by being in constant dialogue with the anthropology of techniques.

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